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Geologic Map of Fannin County,
Texas, Prepared by ADP
Techniques from ERTS
MSS Data

by
J. A. Henderson, Jr.
J. J. Gardner
J. E. Cipra

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AN INTERPRETATION OF A GEOLOGIC MAP OF
FANNIN COUNTY, TEXAS, PREPARED BY ADP
TECHNIQUES FROM ERTS MSS DATA

J.A. Henderson, Jr., J.V. Gardner,
J.E. Cipra*

Laboratory for Applications of Remote
Sensing, Purdue University,
Lafayette, Indiana

Abstract

Multispectral scanner data, collected by ERTS-1 from an area in northeast Texas underlain by structurally simple cretaceous sedimentary rocks, were analyzed using several automatic data processing techniques. Training areas for the computer analysis were selected in three ways using: (1) an unsupervised classifier, (2) the unsupervised classifier to further refine training areas, and (3) available ground information. The first two methods utilize the capability of the unsupervised classifier to group resolution elements with similar spectral properties. With the imagery produced by these procedures, several geologic features can be identified. The most easily recognizable features are streams and other water bodies. The approximate location of contacts between several rock units can be mapped.

*Laboratory for Applications of Remote Sensing and Department of Geosciences, Purdue University; Department of Geography and Geology, Indiana State University; and Laboratory for Applications of Remote Sensing and Department of Agronomy, Purdue University, respectively. This paper was presented at the University of Tennessee Remote Sensing Conference, University of Tennessee Space Institute, Tullahoma, Tennessee, March 26-28, 1973.

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Introduction

An area of relatively simple geology was chosen for testing the geologic mapping capabilities with ADP techniques on ERTS MSS data. MSS data were collected by the Earth Resources Technology Satellite on July 25, 1972. All data analysis was done at the Laboratory for Applications of Remote Sensing (LARS) using general analysis procedures developed at LARS.

Data Collection and Data Processing

The data used for this report are from the multispectral scanner and are in the form of digital computer compatible tapes. The bands of the multispectral scanner are in the visible and near infrared region of the spectrum: channel 4--0.50-0.60 μ m, channel 5--0.60-0.70 μ m, channel 6--0.70-0.80 μ m and channel 7--0.80-1.10 μ m. The LARSYS software system is a package of computer programs, which have been designed to analyze and display remotely sensed multispectral data. Five major processing algorithms were used in this study: (1) CLUSTER, (2) STATISTICS, (3) CLASSIFYPOINTS, (4) PRINTRESULTS, and (5) NEWPHOTO. The CLUSTER processor is an unsupervised classifier that groups data vectors into spectrally distinct classes. Mean vectors and covariance matrices are calculated by the STATISTICS processor and are then used in the CLASSIFYPOINTS processor which performs a maximum likelihood Gaussian classification on a point-by-point basis over the entire area.¹ Results from the above analysis are displayed using: (1) the PRINTRESULTS processor to make alphanumeric maps; and (2) the NEWPHOTO processor to display the results on the digital display*.²

*The Digital Image Display System receives an image from a System/360 computer, stores this data in a video buffer, and displays the image in a raster scanning mode on a standard television screen. An interactive capability to edit, annotate, or modify the image is provided through a light pen and a program function keyboard. An additional³ photographic copying capability is also provided.

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Geology

Fannin County, Texas is in the northwestern part of the Gulf Coastal Plain physiographic province and adjacent to the Ouachita Province. Rocks of Cretaceous age crop out in the Fannin County area and dip south and southeast. A description and map of the rocks in Fannin County are presented in figures 1 and 2.

Procedure

Two types of methods were used to select the training areas from the data for classification. The first type was unsupervised in that the classes were based entirely on spectral differences by use of a clustering algorithm. Manually selected training areas were utilized in the second type of classification using the published map for ground information.

A subset of Fannin County was chosen for classification using an unsupervised classifier (CLUSTER). The fifteen spectral classes defined by the CLUSTER processor were used as the basis for the first classification. A printout map and a photograph from the digital display were made, and these were evaluated.

A second unsupervised classification was made of a slightly larger area, specifying twenty classes. From this printout, areas were selected which contained six adjacent resolution elements in the same class. This was done to eliminate areas which contained points that were influenced by more than one type of surface cover. Using these areas, thirteen unsupervised classifications were performed to determine the number of spectral classes present. The separability information provided by the clustering processor indicated that there were twelve spectral classes in the data. The classes defined by the clustering processor were used to make classifications which were then displayed and evaluated.

Further analysis was done on the two classifications cited above using a procedure developed by the authors and other members of the LARS staff.

<u>Age</u>	<u>Unit</u>	<u>Thickness (ft)</u>	<u>Description</u>
Recent	Alluvium (Qal)	3±	Flood-plain and stream deposits
Pliocene	Fluviatile terrace Deposits (Qt)	30	Terrace deposits generally sands and gravel
Upper Cretaceous	Ozan Fm (Ko)	425±	Poorly bedded calcareous clay, weathers light brownish gray
	Austin Gp.		
	Roxton Limestone (Kr)	10	Sandy, red limestone
	Gober Chalk (Kg)	400±	Argillaceous Chalk weathers white
	Brownstown Marl (Kbr)	30	Massive calcareous clay, weathers light yellowish gray
	Blossom Sand (Kbl)	20	Quartz sand, weathers brown and red
	Bonham Marl (Kbo)	400±	Marl and Clay, weathers light gray to yellowish gray
	Ector Chalk (Kec)	35	Chalk, weathers white
	Eagle Ford Fm. (Kef)	300-400	Medium to Dark Gray Shale
	Woodbine Fm		
	Templeton Mbr. (Kwt)	70-80	Gray shale
	Lewisville Mbr. (Kwl)	75-95	Glauconitic sandstone, gray to brown and yellowish brown
	Red Branch Mbr. (Kwr)	25-80	Sandstone, shale, and lignite, gray, brown, yellowish brown and grayish black

Fig. 1. Geologic Column in Fannin County, Texas⁴

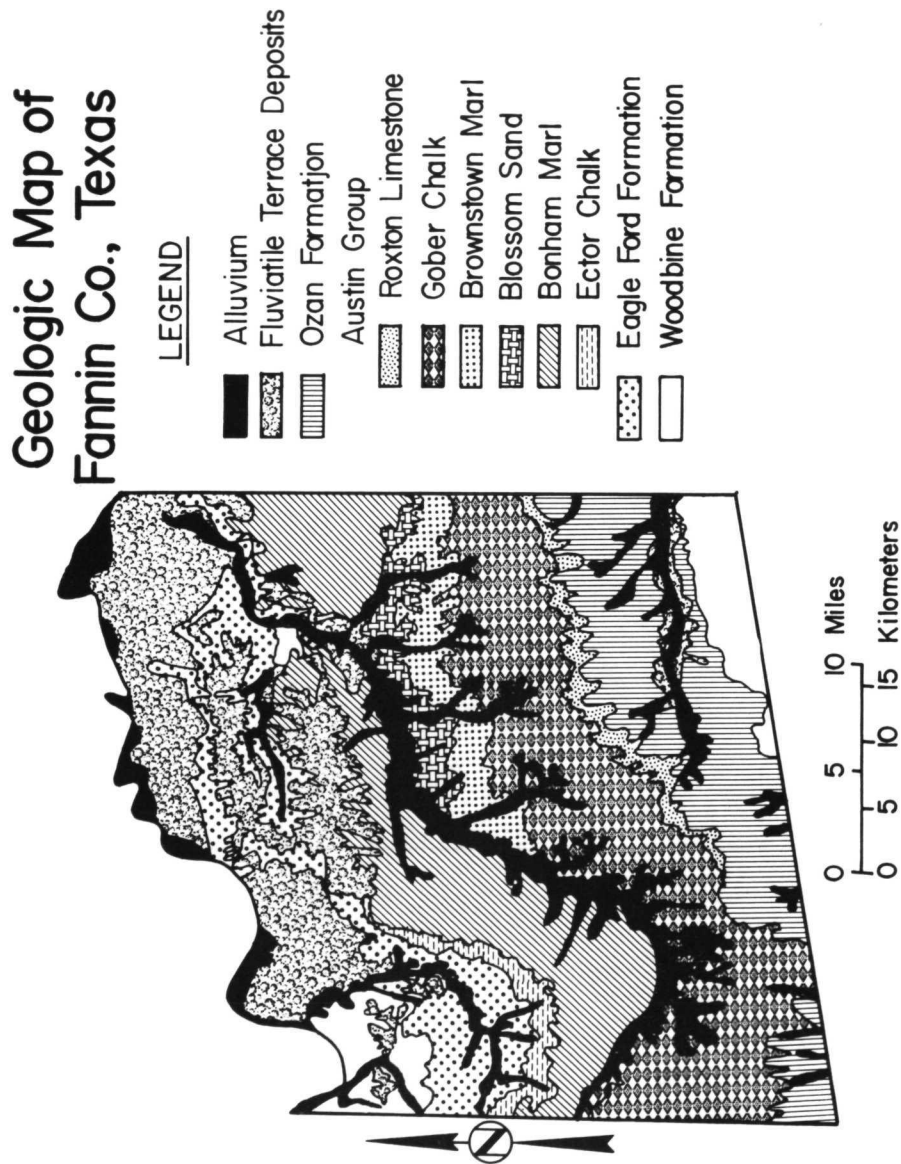


Fig. 2. Geologic map of Fannin County, Texas.

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Ratios of the reflected visible energy (mean values in channels 4 and 5) divided by the reflected infrared energy (mean values in channels 6 and 7)

were calculated $\left(\frac{4+5}{6+7}\right)$ and grouped according to numerical size.

Classes which have similar ratios do not necessarily have similar intensities.

Two methods of manually selecting training areas were investigated: (1) training areas were selected from spectrally heterogeneous ground cover, and (2) training areas were selected from areas believed to be nonvegetated soil. A transparent overlay was made from the geologic map at the same scale as the computer printout map. Using this overlay, training areas were selected from each geologic unit, without regard to surface cover type. These areas were used in the statistics and classification programs. The resulting classification was displayed in printout map form and also on the digital display.

Areas of nonvegetated soil, thought to be cultivated areas, were located and displayed on a printout map. The ratio procedure previously defined was used to identify these areas. Using the geologic overlay, training areas were chosen from nonvegetated areas within the known outcrop area of each rock type, and these were used as a basis for a classification. In addition, training areas of water and vegetation were used in the classification. Results of this classification were also displayed in a printout map and on the digital display.

Results

Classifications of the MSS data were displayed using a line printer and the digital display. Printout maps are generally unsatisfactory for large-scale visual analysis because of their size and resolution limitations. Conversely, the smaller pictures from the digital display allow the researcher the flexibility to make overlays, examine several classifications simultaneously, and compare features in each classification.

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With the LARSYS system it is possible to evaluate a classification qualitatively or quantitatively (percent correct recognition). From a geological viewpoint, a classification was "good" if it showed boundaries between materials regardless of the percent correct recognition. Of the four classifications in this investigation, the most satisfactory results were obtained by using the twelve class unsupervised classification.

One of the most spectrally distinct materials in the MSS data is water. Large rivers, lakes, and some small streams can easily be identified in the classified area. Most of the smaller tributaries are lines with dense green vegetation. They can be visually recognized as streams because of the drainage pattern (dendritic to modified rectangular in Fannin Co.). Figure 3 shows many of the drainage features in Fannin County. This classification

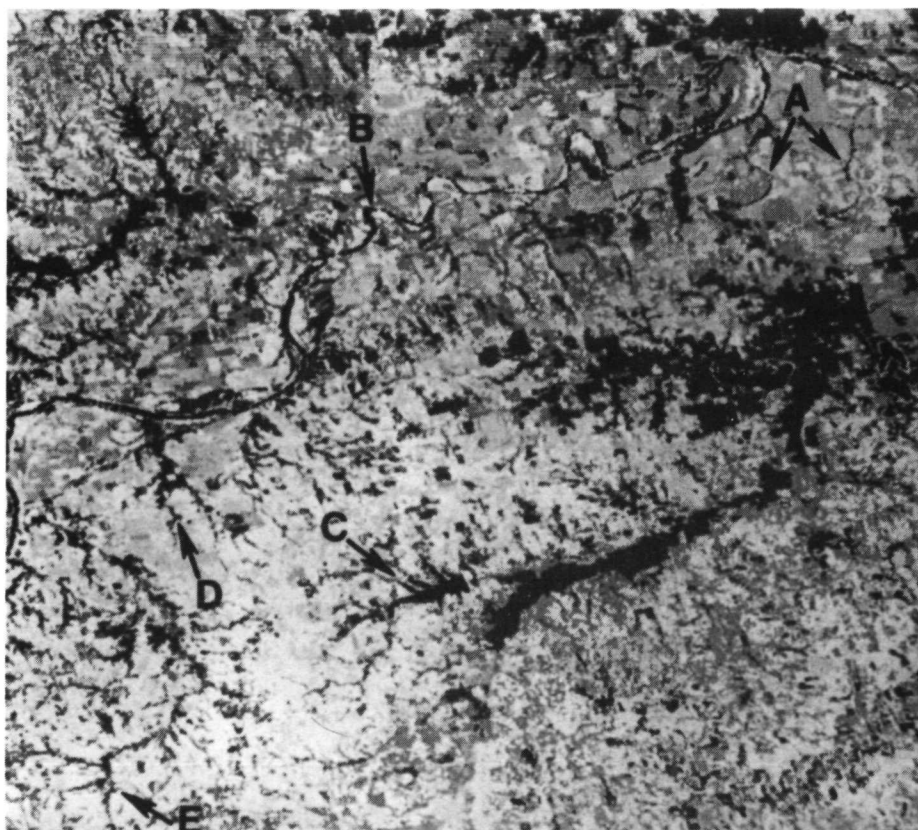


Fig. 3. Drainage features in Fannin County, Texas from computer produced classification results.

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was produced by combining the twelve original classes on the basis of ratios. Several features are apparent on the photograph: A appears to be meander scars made by the Red River, B is an active meander, C is a tributary of one of the reservoirs in the county, and D and E are streams draining into the Red River.

Boundaries were drawn, between apparently different materials, on several of the digital display photos. When these drawn boundaries were compared with a geologic map of similar scale, it was apparent that most of the inferred boundaries were correct. Figure 4 shows the approximate location of mapped contacts between rock units (numbered, dashed lines) and boundaries drawn because of spectral differences (lettered, solid lines). These boundaries were drawn on the original twelve class classification. As can be seen on the photograph, lines A and C and part of lines D and E most nearly match with mapped contacts 1, 2, 3 and 4 respectively. The computer classification shows differences in material at lines B, F, G and H which were not mapped as rock contacts. The apparent discrepancies may be the result of topographic and/or land use effects. Lines A and B mark the approximate edges of a low plateau which may cause the difference in reflectance. Areas enclosed by lines H are thought to be dense green vegetation in the stream valleys.

Conclusions

Geologic reconnaissance mapping can be done using ADP techniques on MSS data for this area of Texas. In conjunction with the remote sensing data, the researcher should have at his disposal reliable ground data on which to base his conclusions. In some instances it may be possible to process the data before ground observations are made, and use the ground observations to verify boundaries established by the computer or to help complete incorrectly or incompletely mapped areas.

The greatest problem associated with the geologic mapping using MSS data is that what is being mapped is not rock but ground cover. To cope with this problem, the researcher assumes that



1. Contact between the Roxton Limestone and the Gober Chalk
2. Contact between the Gober Chalk and the Brownstown Marl
3. Contact between the Bonham Marl and the Ector Chalk
4. Contact between the Ector Chalk and the Eagle Ford Formation

Fig. 4. Geologic interpretation of a computer classification of Fannin County, Texas.

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vegetation and soil are influenced by rock type and change only where the lithology changes. In nonagricultural areas where there is native vegetation, this assumption should hold.

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²Laboratory for Applications of Remote Sensing, 1973, LARSYS User's Manual, T.L. Phillips (Editor), Purdue University, West Lafayette, Indiana. (In Press).

³IBM 4507 Digital Image Display System Maintenance Manual, 1970, p. 1-1.

⁴Bureau of Economic Geology, 1966 and 1967, Geologic Atlas of Texas, "Sherman and Texarkana Sheets," University of Texas, Austin, Texas.